



**UNIVERSITI PUTRA MALAYSIA**

**MASS CULTURE OF ARTHROSPIRA PLATENSIS UTILIZING  
AEROBICALLY DIGESTED PALM OIL MILL EFFLUENT (ADPOME)**

**KENNEDY AARON AGUOL**

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**2003**



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**By**

**KENNEDY AARON AGUOL**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
Fulfilment of the Requirements for the Degree of Master of Science**

**March 2003**



## DEDICATION

Monongkotohuod zou kumaa KINOINGAN sabab nohdo balakat tosimaa kumaa  
doid dogo do nakaanu zou popotuhuk diti projek.

Au ku nogi hivan kumaa di koduvo-duvo zapa om zinaku  
*Bartholomew Quak@ Bartholomew Aguol om Addaline Mabel Chan*

Om nogi kumaa di tobinaiku

*Grace Yvonne Aguol*

Do minanak dogo doh sokodung om koginavaan ie togiot kopizo.

This thesis was written as a dedication to all researchers and scientist who had  
contributed directly and indirectly in the quest of knowledge.

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in  
fulfilment of the requirement for the degree of Master of Science

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**By**

**KENNEDY AARON AGUOL**

**March 2003**

**Chairman : Dr. Hishamuddin Bin Omar**

**Faculty: Science and Environmental Studies**

A series of experiments were conducted to develop a mass culture technique of *Arthrospira platensis*, a blue-green alga, in freshwater and brackishwater (15 ppt) using different concentrations (1, 2, 3, 4 and 5%) of aerobically digested palm oil mill effluent (ADPOME) in two trials. The cell growth, chlorophyll *a*, total protein, carbohydrate, lipid contents and fatty acid profile were also studied. Physio-chemical water quality parameters (temperature, dissolved oxygen, pH, salinity, surface irradiance, underwater irradiance, optical density, total ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, total nitrogen, phosphate phosphorus, total phosphorus, chemical oxygen demand, biochemical oxygen demand and total dissolved organic carbon) were also measured throughout the study.

Algal cell growth was best in 4% ADPOME, both in the freshwater and brackishwater conditions and culture cycles with mean cell dry weight of  $706.98 \pm 285.52$  and  $479.79 \pm 204.53$  mg L<sup>-1</sup>, respectively. The highest chlorophyll *a* content

was also observed in *A. platensis* cultivated in 4% ADPOME, in both freshwater and brackishwater conditions from both culture trials with mean chlorophyll *a* content at  $10.12 \pm 6.10$  and  $8.40 \pm 5.23 \text{ mgL}^{-1}$ , respectively.

*A. platensis* cultivated in 1% ADPOME yielded the highest total protein content in freshwater and brackishwater from both culture trials at  $69.60 \pm 1.09$  and  $58.71 \pm 3.73$  % dry weight ( $p < 0.05$ ) when compared to other treatments. The highest total lipid content was observed in *A. platensis* that were cultivated in 5% ADPOME from both freshwater and brackishwater and culture trials at  $7.03 \pm 0.13$  and  $10.08 \pm 0.01$ , respectively. Similarly, the maximum total carbohydrate content were also observed when *A. platensis* was cultivated in 5% ADPOME at  $25.47 \pm 0.36$  and  $33.39 \pm 1.17$  % dry weight, respectively in both freshwater and brackishwater and culture trials. *A. platensis* cultured in 4% ADPOME had the most diverse fatty acid composition from both freshwater and brackishwater and culture trials.

Finally, the results of physio-chemical water quality from different concentrations of ADPOME both in the freshwater and brackishwater indicated that *A. platensis* has the ability to bioremediate organic rich palm oil mill effluent by reducing the retention time from 3-4 weeks to 1 week and improve the general water quality of the effluent.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**PENGKULTURAN SECARA BESAR-BESARAN *ARTHROSPIRA PLATENSIS* MENGGUNAKAN KUMBAHAN MINYAK KELAPA SAWIT DIHADAM**

Oleh

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Satu siri eksperimen-eksperimen telah dijalankan untuk membangunkan kaedah pengkulturan secara besar besaran *Arthrospira platensis*, sejenis alga biru-hijau, dalam air tawar dan air payau (15 ppt) menggunakan kepekatan yang berbeza (1, 2, 3, 4 dan 5%) kumbahan minyak kelapa sawit dihadapam aerobik (ADPOME) dalam dua percubaan pengkulturan. Tumbesaran sel, kandungan klorofil *a*, kandungan menyeluruh protein, lipid, karbohidrat dan profil asid lemak juga telah dikaji. Parameter-parameter mutu air fiziko-kimia (suhu, oksigen terlarut, pH, saliniti, irradian permukaan, irradian dalam air, ketumpatan optik, jumlah amonia nitrogen, nitrat nitrogen, nitrit nitrogen, jumlah nitrogen, fosfat fosforus, jumlah fosforus, keperluan oksigen kimia, keperluan oksigen biokimia dan jumlah karbon organik terlarut) turut disukat sepanjang kajian tersebut.

Tumbesaran sel terbaik telah diperolehi daripada 4% ADPOME, dalam kedua-dua persekitaran air tawar dan air payau dan kitaran pengkulturan dengan min berat sel kering pada  $706.98 \pm 285.52$  dan  $479.79 \pm 204.53 \text{ mgL}^{-1}$ , masing-masing.

Kandungan klorofil *a* tertinggi juga diperoleh daripada *A. platensis* yang dikultur dalam 4% ADPOME dalam kedua-dua persekitaran air tawar dan air payau dan percubaan pengkulturan dengan min kandungan klorofil *a* pada  $10.12 \pm 6.10$  dan  $8.40 \pm 5.23 \text{ mgL}^{-1}$ , masing-masing.

*A. platensis* yang dikultur menggunakan 1% ADPOME menghasilkan kandungan menyeluruh protein tertinggi dalam persekitaran air tawar dan air payau pada kedua-dua percubaan pengkulturan pada  $69.60 \pm 1.09$  dan  $58.71 \pm 3.73$  % berat kering ( $p < 0.05$ ) apabila dibandingkan dengan rawatan lain. Kandungan tertinggi lipid menyeluruh diperoleh dalam *A. platensis* yang dikultur menggunakan 5% ADPOME dalam persekitaran air tawar dan air payau pada kedua-dua percubaan pengkulturan dengan min kandungan lipid  $7.03 \pm 0.13$  dan  $10.08 \pm 0.01$ , masing-masing. Seperkara, kandungan menyeluruh karbohidrat maksima juga diperoleh dalam *A. platensis* yang dikultur menggunakan 5% ADPOME pada  $25.47 \pm 0.36$  dan  $33.39 \pm 1.17$  % berat kering, masing-masing. *A. platensis* yang dikultur menggunakan 4% ADPOME memiliki komposisi asid lemak yang paling pelbagai dalam kedua-dua percubaan pengkulturan dan persekitaran air tawar dan air payau.

Keputusan mutu air fiziko-kimia daripada kepekatan ADPOME yang berbeza dari kedua-dua persekitaran air tawar dan air payau menunjukkan *A. platensis* memiliki keupayaan dalam bioremediasi kumbahan minyak kelapa sawit yang kaya dengan bahan organik dengan mengurangkan masa simpanan daripada 3-4 minggu ke 1 minggu serta memperbaiki mutu air kumbahan secara umum.



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I certify that an Examination Committee met on 3<sup>rd</sup> March 2003 to conduct the final examination of Kennedy Aaron Aguol on his Master of Science thesis entitled “Mass Culture Of *Arthrospira platensis* Utilising Aerobically Digested Palm Oil Mill Effluent (ADPOME)” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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## DECLARATION FORM

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



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KENNEDY AARON AGUOL

Date: 28<sup>th</sup> APRIL 2003

## TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL SHEETS	viii
DECLARATION	x
LIST OF TABLES	xv
LIST OF FIGURES	xvi
LIST OF ABBREVIATIONS	xxii
LIST OF PLATES	xxiv
<b>CHAPTER</b>	
1 INTRODUCTION	1
2 Literature Review	6
2.0 Introduction	6
2.1 Blue Green Alga Classification	6
2.2 Description of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	6
2.3 Biochemistry of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	10
2.3.1 Protein and Amino Acid of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	10
2.3.2 Lipid	11
2.3.3 Essential Fatty Acid	15
2.3.3.1 Glycolipids and Sulfolipids	17
2.3.4 Carbohydrate	17
2.3.5 Vitamins	17
2.3.6 Minerals	18
2.3.7 Phytonutrients	19
2.4 The Benefit and Uses of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	20
2.4.1 Economic and Nutraceutical Potential of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	20
2.4.2 Therapeutic Properties of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	22
2.4.2.1 Therapeutic Feeding	22
2.4.2.2 Wound Healing	22
2.4.2.3 Anti-cancer Properties of Phycocyanin and $\beta$ -carotene content	23
2.4.2.4 $\gamma$ -Linolenic Acid (GLA) and Prostaglandin Stimulation	23
2.5 The History and Progress of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> ) cultivation	24
2 6 <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> ) Cultivation Techniques	24

2.6.1	Main Advantages of Culturing Microalgae as a source of biomass	24
2.6.2	Microalgal Growth	25
2.6.3	Factors Influencing Microalgae Growth	27
2.6.4	Light	27
2.6.5	pH	28
2.6.6	Temperature	28
2.6.7	Salinity	29
2.6.8	Agitation and Aeration	30
2.6.9	Ammonia	30
2.6.10	Culture Purity	31
2.6.11	Seawater	31
2.6.12	Sheltered Mass Culture	31
2.7	Utilization of Agroindustrial Wastewater As Alternative Growth Media for <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	32
2.7.1	Palm Oil Mill Effluent (POME)	32
3.0	MATERIALS AND METHODS	35
3.1	Pure Culture and Isolation of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	35
3.2	Culture of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> ) in Kosaric Media	38
3.3	Stock Culture for Upscale Cultivation	38
3.4	Dechlorinated Freshwater and Brackishwater Preparation	39
3.5	Culture Intermediate and Acclimatization Stage	41
3.6	Shaded Mass Culture	41
3.7	Collection of Raw Palm Oil Mill Effluent (POME)	43
3.8	Freeze dried Raw Palm Oil Mill Effluent (POME)	44
3.9	Preparation of Aerobically Digested Raw POME (ADPOME) In Freshwater and Brackishwater	44
3.10	Preparation of Culture Media Using ADPOME	46
3.11	<i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> ) cultivation under different concentrations of ADPOME in Freshwater and Brackishwater	46
3.12	Growth Performance Determination of <i>Spirulina platensis</i> ( <i>Arthrospira platensis</i> )	48
3.12.1	Cell dry weight determination	48
3.12.2	Chlorophyll <i>a</i> content	48
3.13	Water Quality Determination of <i>S. platensis</i> ( <i>A. platensis</i> ) culture	50
3.13.1	Physical Water Quality Parameters	50
3.13.2	Chemical Water Quality Parameters	50
3.13.2.1	Total Nitrogen (TN)	50
3.13.2.2	Total Phosphorus (TP)	51
3.13.2.3	Phosphate-phosphorus (PO <sub>4</sub> -P)	52
3.13.2.4	Total Ammonia Nitrogen (TAN)-(NH <sub>4</sub> -N)	53
3.13.2.5	Nitrite-Nitrogen (NO <sub>2</sub> -N)	54
3.13.2.6	Nitrate-Nitrogen (NO <sub>3</sub> -N)	55

3.13.2.7	Total Dissolved Organic Carbon (T <sub>d</sub> OC)	56
3.13.2.8	Biochemical Oxygen Demand (BOD <sub>5</sub> )	57
3.13.2.9	Chemical Oxygen Demand (COD)	58
3.14	Cell Harvesting Technique	59
3.15	Freeze Drying	60
3.16	Nutritional Content Analysis	60
3.16.1	Total Protein	60
3.16.2	Total Lipid	61
3.16.3	Total Carbohydrate	62
3.16.4	Fatty Acid Methyl Esters (FAMES) Preparation	63
3.16.5	Fatty Acid Detection Using Shimadzu Gas Chromatography GC-8A	65
3.17	Statistical Analysis	66
4.0	RESULTS	
4.1	Cell Dry Weight of <i>Spirulina platensis</i> Cultured in Freshwater and Brackishwater	67
4.2	Chlorophyll <i>a</i> content of <i>Spirulina platensis</i> Cultured in Freshwater and Brackishwater	70
4.3	Nutritional Content of <i>Spirulina platensis</i>	
4.3.1	Total Protein Content of <i>Spirulina platensis</i> Cultured in Freshwater and Brackishwater	75
4.3.2	Total Lipid Content of <i>Spirulina platensis</i> Cultured in Freshwater and Brackishwater	79
4.3.3	Total Carbohydrate Content of <i>Spirulina platensis</i> Cultured in Freshwater and Brackishwater	82
4.4	Fatty Acid Composition of <i>Spirulina platensis</i>	
4.4.1	Fatty Acid Composition of <i>Spirulina platensis</i> Cultured in Freshwater	87
4.4.2	Fatty Acid Composition of <i>Spirulina platensis</i> Cultured In Brackishwater	88
4.5	Physical Water Quality Parameters	
4.5.1	Temperature of Freshwater and Brackishwater Culture	93
4.5.2	Dissolved Oxygen of Freshwater and Brackishwater Culture	95
4.5.3	pH of Freshwater and Brackishwater Culture	97
4.5.4	Salinity of Freshwater and Brackishwater Culture	99
4.5.5	Surface Irradiance of Freshwater and Brackishwater Culture	101
4.5.6	Underwater Irradiance of Freshwater and Brackishwater Culture	103
4.5.7	Optical Density in Freshwater and Brackishwater Culture	105

4.6 Chemical Water Quality Parameters	107
4.6.1 Total Ammonia Nitrogen (TAN) in Freshwater and Brackishwater Culture	108
4.6.2 Nitrate Nitrogen (NO <sub>2</sub> -N) in Freshwater and Brackishwater Culture	110
4.6.3 Nitrite Nitrogen (NO <sub>3</sub> -N) in Freshwater and Brackishwater Culture	112
4.6.4 Total Nitrogen (TN) in Freshwater and Brackishwater Culture	114
4.6.5 Phosphate Phosphorus (PO <sub>4</sub> -P) in Freshwater and Brackishwater Culture	116
4.6.6 Total Phosphorus (TP) in Freshwater and Brackishwater Culture	118
4.6.7 Chemical Oxygen Demand (COD) in Freshwater and Brackishwater Culture	120
4.6.8 Biochemical Oxygen Demand (BOD <sub>5</sub> ) in Freshwater and Brackishwater Culture	122
4.6.9 Total Dissolved Organic Carbon (T <sub>d</sub> OC) in Freshwater and Brackishwater Culture	124
 5.0 DISCUSSION	 126
 6.0 CONCLUSION	 141
 REFERENCES/BIBLIOGRAPHY	 143
 APPENDICES	 157
 BIODATA OF AUTHOR	 198



## LIST OF TABLES

Table		Page
1	The amino acid profile of <i>Spirulina platensis</i> ( <i>A. platensis</i> )	11
2	The total protein content of <i>Spirulina platensis</i> ( <i>A. platensis</i> ) and other protein food sources	11
3	The essential fatty acids of <i>Spirulina platensis</i> ( <i>A. platensis</i> )	17
4	The vitamin content of <i>Spirulina platensis</i> ( <i>A. platensis</i> )	18
5	Comparison of nutritional content of some commercial microalga	21
6	Chemical composition (dry weight) in palm oil mill effluent	33
7	Fatty acid composition (% of total FAME) of <i>S. platensis</i> cultured in freshwater under different ADPOME concentrations from culture cycle 1. Values are expressed as mean of two replicates. Means in the same row with identical lettering are not significantly different ( $P<0.05$ ).	89
8	Fatty acid composition (% of total FAME) of <i>S. platensis</i> cultured in freshwater under different ADPOME concentrations from culture cycle 2. Values are expressed as mean of two replicates. Means in the same row with identical lettering are not significantly different ( $P<0.05$ ).	90
9	Fatty acid composition (% of total FAME) of <i>S. platensis</i> cultured in brackishwater under different ADPOME concentrations from culture cycle 1. Values are expressed as mean of two replicates. Means in the same row with identical lettering are not significantly different ( $P<0.05$ ).	91
10	Fatty acid composition (% of total FAME) of <i>S. platensis</i> cultured in brackishwater under different ADPOME concentrations from culture cycle 2. Values are expressed as mean of two replicates. Means in the same row with identical lettering are not significantly different ( $P<0.05$ ).	92
11	Comparison of nutritional composition of <i>S. platensis</i> cultured in different agro-industrial effluent.	133
12	Comparisons of fatty acid composition of freeze dried raw palm oil mill effluent (POME), <i>S. platensis</i> cultured in Kosaric media, freshwater and brackishwater.	136
13	% Difference of mean dry cell biomass from two culture cycles between freshwater and brackishwater culture from this project.	138

## LIST OF FIGURES

Figure		Page
1	Mean values biomass concentration ( $\text{mg L}^{-1}$ dry weight) of <i>S. platensis</i> cultured in freshwater under different ADPOME concentrations from two culture cycles	68
2	Mean values biomass concentration ( $\text{mg L}^{-1}$ dry weight) of <i>S. platensis</i> cultured in brackishwater under different ADPOME concentrations from two culture cycles	69
3	Comparison mean values biomass concentration ( $\text{mg L}^{-1}$ dry weight) of <i>S. platensis</i> between freshwater and brackishwater condition from two culture cycles	69
4	Mean values chlorophyll <i>a</i> content ( $\text{mg L}^{-1}$ ) of <i>S. platensis</i> cultured in freshwater under different ADPOME concentrations from two culture cycles	71
5	Mean values chlorophyll <i>a</i> content of <i>S. platensis</i> ( $\text{mg L}^{-1}$ ) cultured in brackishwater under different ADPOME concentrations from two culture cycles	71
6	Comparison mean values chlorophyll <i>a</i> content ( $\text{mg L}^{-1}$ ) of <i>S. platensis</i> between freshwater and brackishwater condition from two culture cycles	72
7	The relationship between biomass concentration ( $\text{mg L}^{-1}$ ) and chlorophyll <i>a</i> content ( $\text{mg L}^{-1}$ ) of <i>S. platensis</i> in freshwater and brackishwater condition under different ADPOME concentrations (Control, 1% and 2% ADPOME) from two culture cycles	73
8	The relationship between biomass concentration ( $\text{mg L}^{-1}$ ) and chlorophyll <i>a</i> content ( $\text{mg L}^{-1}$ ) of <i>S. platensis</i> in freshwater and brackishwater condition under different ADPOME concentrations (3%, 4% and 5%ADPOME) from two culture cycles	74
9	Mean values total protein content (% dry weight) of <i>S. platensis</i> cultured in freshwater using different concentration of ADPOME from two culture cycles	76
10	Mean values total protein content (% dry weight) of <i>S. platensis</i> cultured in brackishwater using different concentration of ADPOME from two culture cycles	77
11	Comparison of mean values total protein content (% dry weight) in <i>Spirulina platensis</i> between freshwater and brackishwater condition from two culture cycles	77

12	The relationship between different ADPOME concentration and total protein content (% dry weight) of <i>S. platensis</i> in freshwater and brackishwater condition from two culture cycles.	78
13	Mean values total lipid content (% dry weight) of <i>S. platensis</i> cultured in freshwater using different concentration of ADPOME from two culture cycles	80
14	Mean values total lipid content (% dry weight) of <i>S. platensis</i> cultured in brackishwater using different concentration of ADPOME from two culture cycles	80
15	Comparison of mean values total lipid contents (% dry weight) in <i>Spirulina platensis</i> between freshwater and brackishwater condition from two culture cycles	81
16	The relationship between different ADPOME concentration and total lipid content (% dry weight) of <i>S. platensis</i> in freshwater and brackishwater condition from two culture cycles	82
17	Mean values total carbohydrate content (% dry weight) of <i>S. platensis</i> cultured in freshwater using different concentration of ADPOME from two culture cycles	83
18	Mean values total carbohydrate content (% dry weight) of <i>S. platensis</i> cultured in brackishwater using different concentration of ADPOME from two culture cycles	84
19	Comparison of mean values total carbohydrate contents (% dry weight) in <i>Spirulina platensis</i> between freshwater and brackishwater condition	84
20	The relationship between different ADPOME concentration and total carbohydrate content (% dry weight) of <i>S. platensis</i> cultured in freshwater and brackishwater condition from two culture cycles	85
21	Comparison of mean values total protein, lipid and carbohydrate content (% dry weight) in <i>Spirulina platensis</i> between freshwater and brackishwater culture	86
22	The relationship between different ADPOME concentration and total protein, lipid and carbohydrate content (% dry weight) of <i>S. platensis</i> in freshwater and brackishwater condition from two culture cycles	86
23	Mean values of temperature (°C) variation under different ADPOME concentrations in freshwater condition from two culture cycles	94

24	Mean values of temperature ( $^{\circ}\text{C}$ ) variation under different ADPOME concentrations in brackishwater condition from two culture cycles	94
25	Comparison of mean values temperature ( $^{\circ}\text{C}$ ) variation under different ADPOME concentrations in freshwater and brackishwater condition from two culture cycles	95
26	Mean values of dissolved oxygen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater condition from two culture cycles	96
27	Mean values of dissolved oxygen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	96
28	Comparison of mean values dissolved oxygen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater condition from two culture cycles	97
29	Mean values of pH variation under different ADPOME concentrations in freshwater condition from two culture cycles	98
30	Mean values of pH variation under different ADPOME concentrations in brackishwater condition from two culture cycles	98
31	Comparison of mean values pH variation under different ADPOME concentrations in freshwater and brackishwater condition from two culture cycles	99
32	Mean values of salinity (ppt) variation under different ADPOME concentrations in freshwater from two culture cycles	100
33	Mean values of salinity (ppt) variation under different ADPOME concentrations in brackishwater from two culture cycles	100
34	Comparison of mean values salinity (ppt) variation under different ADPOME concentrations in freshwater and brackishwater condition from two culture cycles	101
35	Mean values of surface irradiance ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	102
36	Mean values of surface irradiance ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	102

37	Comparison means values surface irradiance ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	103
38	Mean values of underwater irradiance ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	104
39	Mean values of underwater irradiance ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	104
40	Comparison means values underwater irradiance ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	105
41	Mean values of optical density (560nm) variation under different ADPOME concentrations in freshwater from two culture cycles	106
42	Mean values of optical density (560nm) variation under different ADPOME concentrations in brackishwater from two culture cycles	106
43	Comparison means values optical density ( $\text{OD}_{560}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	107
44	Mean values of total ammonia nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	108
45	Mean values of total ammonia nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	109
46	Comparison means values total ammonia nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	109
47	Mean values of nitrate nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	110
48	Mean values of nitrate nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	111
49	Comparison means values nitrate nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	111

50	Mean values of nitrite nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	112
51	Mean values of nitrite nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	113
52	Comparison means values nitrite nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	113
53	Mean values of total nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	114
54	Mean values of total nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	115
55	Comparison means values total nitrogen ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	115
56	Mean values of phosphate-phosphorus ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	116
57	Mean values of phosphate-phosphorus ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	117
58	Comparison means values phosphate-phosphorus ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	117
59	Mean values of total phosphorus ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	118
60	Mean values of total phosphorus ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	119
61	Comparison means values total phosphorus ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	119
62	Mean values of chemical oxygen demand ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	120
63	Mean values of chemical oxygen demand ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	121



64	Comparison means values chemical oxygen demand ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	121
65	Mean values of biochemical oxygen demand ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	122
66	Mean values of biochemical oxygen demand ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	123
67	Comparison means values biochemical oxygen demand ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	123
68	Mean values of total dissolved organic carbon ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater from two culture cycles	124
69	Mean values of total dissolved organic carbon ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in brackishwater from two culture cycles	125
70	Comparison means values total dissolved organic carbon ( $\text{mg L}^{-1}$ ) variation under different ADPOME concentrations in freshwater and brackishwater from two culture cycles	125

## LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ADPOME	Aerobically digested palm oil mill effluent
ASEAN	Association of South East Asian Nation
BF <sub>3</sub>	Boron trifluoride
BOD <sub>5</sub>	Biochemical oxygen demand
CH <sub>3</sub>	Methyl group
CHCl <sub>3</sub>	Chloroform
COD	Chemical oxygen demand
COOH	Carboxyl
DHA	Docosahexaenoic acid
DV	United States Daily value
EFA	Essential fatty acid
EPA	Eicosapentanoic acid
FAMES	Fatty acid methyl esters
FeEDTA	Ferric ethylenediaminetetra-acetic acid
FEP	Teflon
FFB	Fresh fruit bunches
GLs	galactolipids
GLA	Gamma linolenic acid
HCl	Hydrochloric acid
H <sub>2</sub> SO <sub>4</sub>	Sulphuric acid
IU	International unit
Ig E	Immunoglobulin E
mgL <sup>-1</sup>	Milligram per litre
µm	Micro meter
µl	Micro litre
MUFA	Mono unsaturated fatty acid
N	Normality
NaOH	Sodium hydroxide
NED	N-1-Naphthylenediamine dihydrochloride
NO <sub>2</sub> -N	Nitrite-nitrogen



NO <sub>3</sub> -N	Nitrate-nitrogen
NPK	Nitrogen Phosphorus Potassium (Kalium)
PGE <sub>1</sub>	Prostaglandin
PO <sub>4</sub> -P	Phosphate-phosphorus
POME	Palm oil mill effluent
ppt	Parts per thousand
PUFA	Poly unsaturated fatty acid
rpm	Revolution per minute
SFA	Saturated fatty acid
TAN-(NH <sub>4</sub> -N)	Total Ammonia Nitrogen
T <sub>d</sub> OC	Total dissolved organic carbon
TN	Total Nitrogen
TP	Total Phosphorus
UM	Universiti Malaya
UMS	Universiti Malaysia Sabah
UPM	Universiti Putra Malaysia
UNIDO	United Nation Industrial Development Organization
UV	Ultra violet
WHO	World Health Organisation
YSI	Yellow spring instrument